58. (Amended) A method for manufacturing coated workpieces comprising the steps of

introducing a workpiece into a sputtering chamber,

rotating said workpiece about a rotational axis,

providing a sputtering source with a sputtering surface and having a central axis which is oblique with respect to said rotational axis at an angle of less than 90°,

sputter coating said workpiece by said source thereby providing at said source at least one closed-loop, tunnel-shaped magnetic field pattern with a constant field-polarity considered in a direction along said closed loop.

D1

REMARKS

In view of the separate attached letter requesting drawing change approval, the objection to Figs. 2a and 2b is deemed fully addressed with the understanding that the deleted modified versions are still contemplated and encompassed by the present invention.

The objection to Claims 49 [sic, 48], 50, 58 and 59 as well as the rejection of Claims 35-57 under 35 USC § 112, ¶ 2, are deemed overcome by the above amendments.

The rejection of Claims 35, 37, 42, 43, 57 and 58 as being anticipated by DE '592 under 35 USC § 102(b), of Claim 44 as being unpatentable over DE '592 in view of JP '568 under 35 USC § 103(a), the rejection of Claim 56 as being unpatentable over DE '592 in view of Tateshi or Moslehi under 35 USC § 103(a),

the rejection of Claim 56 as being unpatentable over DE '592 in view of Yamanishi under 35 USC §103(a), the rejection of Claims 35-38, 42-44, 46-50 and 56-58 as being unpatentable over JP '568 in view of Yamanishi under 35 USC § 103(a), and the rejection of Claims 35, 37-43, 45, 57 and 58 as being unpatentable over "the prior art (Yamanishi)" in view of "the description of the invention of Yamanishi" under 35 USC § 103(a) are traversed. Reconsideration is requested on the following grounds.

As was pointed out during the interview on October 22, 2002, the DE '592 document is directed to a method in which, just with an Rf sputter process, an oxidic intermediate layer can be provided epitactically on a substrate which comprises at least silicon to reduce the danger of generating an amorphous silicon oxide layer. An Rf magnetron or another Rf source can be used as a sputter source 6. The Rf magnetron, which is shown with concentric electrodes, is formed by a closable opening 7 into the inner space 8 of the chamber 3, so that the plane of its surface forms with the plane of the surface of the substrate 5 a predetermined angle α or is parallel thereto. The angle α has a value anywhere between 0 and 90.

The difference between the DE '592 sputtering chamber and the sputtering chamber as defined in Claim 35 is that the latter requires at least one closed-loop, tunnel-shaped magnetic field pattern around the first axis, which magnetic field has a constant field polarity taken in a direction along the closed loop.

The problems sought to be solved by the DE '592 method (deposition of an epitaxial layer) and by the present invention (reaching uniform film thickness distribution) are so completely different that it could well be that the DE '592 sputter chamber has a non-closed-loop, tunnel-shaped magnetic field and a non-constant field polarity to achieve its objectives. For the present invention, however, such magnetic field and constant field polarity are essential features. The DE '592 method even proposes to locate the two planes of the new sputter surface and of the substrate in parallel without any preference to have the two planes oblique as claimed herein. The fact, too, of having two oblique planes is another essential feature to achieve a uniform film thickness distribution. The planes in the DE '592 method can be parallel so that it is clear that the obliqueness is not an essential feature of that method and is not suggestive of the present invention.

In the JP '568 document, a sputtering source with a target 1 is shown. The Examiner has sketched a magnetic field in the Office Action, which magnetic field is generated by the magnet arrangement 2. The angle between the surface of the substrate 5 and the plane of the new surface of the target 1 is indicated to be

$$60° \leq \phi \leq 90°$$

An object of the JP '568 sputtering chamber is to prevent the incidence of high energy particles to the substrate 5 and to produce a thin film without re-sputtering.

The difference between the JP '568 sputtering chamber and that of Claim 35 is that the former does not provide for a closed loop, tunnel-shaped magnetic field pattern and further does not provide for the substrate being drivingly rotatable. The object of the JP '568 arrangement is to prevent incidence of high-energy particles. This can be realized by tilting the surface of the substrate with respect to the surface of the target up to 90°. Nevertheless, provision of a closed loop, tunnel-shaped magnetic field and of a substrate rotatable relative to the target are clearly not features that would have been suggested or intended in an arrangement whose object is preventing high-energy particles from impinging onto the substrate 5.

The JP '568 sputtering chamber does not teach or even suggest providing the claimed magnetic field pattern and does not teach rotating the substrate relative to the target. Whenever the plane of the substrate and the plane of the target are located at an angle of 90°, the respective axes would not likely be construable as "oblique" to one another.

The Yamanishi et al. apparatus and method do not add anything material to what is taught in either the DE '592 document or the JP '568 document. To demonstrate this, applicants attach Figs. 10 and 12 of the Yamanishi et al. patent showing a conventional magnetron sputtering electrode along with a hand-drawn sketch on the right of the electrical and magnetic fields of the illustrated prior art in those figures.

The most important features of the Yamanishi et al. prior art magnetic field pattern which define a magnetron sputtering source are the magnetic filed

being tunnel-shaped upon the target surface, the tunnel-shaped magnetic field forming a closed loop, and when traveling along the tunnel in one direction (marked by "X" in the enclosed sketch), the magnetic field will not change polarity, i.e., it will always have a right-hand to left-hand polarity or vice versa, as clearly shown in Fig. 10. Such a closed loop, tunnel-shaped magnetic field may be applied regardless of whether the target surface is rectangular or elliptical.

This type of magnetic field pattern forms a so-called "electron trap." This is because the target electrode forms, electrically, a cathode so that, besides the closed loop tunnel magnetic field, there an electric field E is created which crosses the magnetic field pattern as shown schematically by the attached hand-drawn sketch. Electrons are moved by the electric fields away from the cathode as indicated by "v". Thus, the electrical charge moves perpendicularly to the magnetic field. Consequently, the so-called Lorenz-force occurs to drive the electrons along the direction by the X around the magnetic field tunnel in Fig. 10 of the Yamanishi et al. patent.

For sputtering, this trap leads to an increase of the electron density in the area of the tunnel-shaped magnetic field. Due to the closed loop magnetic filed pattern, the electrons are constrained, as a practical matter, to travel around such loop. The increase of electron density along the electron trap leads to an increase of electron impact on gas molecules, e.g., of the working gas for the plasma, and this leads to increase of density of positive ions along such electron trap. That is, along the electron trap the plasma density is increased.

Because a sputtering effect is caused by impact of positive ions on the negatively biased target cathode, an area of increased sputtering adjacent to and along the closed loop tunnel-shaped magnetic field pattern as seen in Figs. 14A-15B of the Yamanishi et al. patent. This phenomenon is commonly referred to as the "race track of a magnetron."

In other words, it is essential for a magnetron to have a closed loop, tunnel-shaped magnetic field pattern as shown in Fig. 10 of the Yamanishi et al. patent and Fig. 3 of the present application showing two tunnel-shaped magnetic field patterns and the resulting magnetron race track shown as a closed loop by the dash lines.

The Yamanishi et al. invention departed from the prior art magnetron sputtering of Fig. 10 by using the magnetic field shown in Fig. 3A, wherein along a square target the polarity of the magnetic filed is subsequently inverted. The direction of force 26 is subsequently inverted when propagating in one direction along the square target. This means that the magnetron effect will not occur. As the electrons travel along the force directions 26 subsequent inversion of driving force will stop such electrons so that, due to the electrical field, they will quickly leave the target area and will not provide for a significant increase of ion density in that target area. This is to be contrasted to the magnetron of Fig. 10, in which the electrons are loaded by a constant one-directional force, and thus acceleration in x direction, and thereby reach a much higher impulse for ionization than will be reached in the Fig. 3A target, where the electrons are subjected to a stop-and-go force.

In Fig. 2 of the Yamanishi et al. patent, the target of Fig. 3A forms an arrangement in which the axis is oblique. It is, however, not the prior art magnetron sputtering source shown in Fig. 10, but only the non-magnetron sputtering source of Fig. 3A that is arranged with the oblique relationships. In other words, the Yamanishi et al. patent proposes to improve homogeneous erosion of the target over the prior art magnetron sputtering shown in Fig. 10 by applying a non-magnetron sputtering source with the geometry shown in Figs. 2, 3A and 3B. The Yamanishi et al. patent teaches away from the kind of magnetic sputtering used in the present invention.

That is, the present invention recognizes that it is advantageous to use the conventional magnetron sputtering source shown in Fig. 10 of Yamanishi et al. and maintain the disadvantage of that magnetron sputtering source, namely inhomogeneously consumed target (racing tracks) in order to achieve an improved homogeneity of layer thickness deposited on the substrate at a very high deposition rate.

Whereas the Yamanishi et al. invention focuses on a target cathode that is more homogeneously consumed compared with a conventional magnetron sputtering cathode, by a specific geometric arrangement of target and substrate, it would not have been obvious to increase homogeneity of the layer thickness as deposited on a substrate and also use higher-rate magnetron sputtering, accepting inhomogeneous target consumption, or racing tracks, by an equal geometric arrangement. The Yamanishi et al. patent would not have taught one skilled in the art to reapply a magnetron sputtering source when that patent

says such a source should be avoided to achieve improved layer thickness homogeneity at the substrate.

For the foregoing reasons, reconsideration of all the rejections and favorable action on the claims are earnestly solicited.

If there are any questions regarding this amendment or the application in general, a telephone call to the undersigned would be appreciated since this should expedite the prosecution of the application for all concerned.

If necessary to effect a timely response, this paper should be considered as a petition for an Extension of Time sufficient to effect a timely response, and please charge any deficiency in fees or credit any overpayments to Deposit Account No. 05-1323 (Docket #622/48561).

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES

IN THE CLAIMS:

35. (Amended) Sputtering chamber comprising at least one sputtering source with a new sputter surface at least approximately symmetrical with respect to a first axis[,] oriented perpendicular [on] to said new sputter surface, a substrate carrier which is arranged to be drivingly rotatable about a second axis, wherein said first and said second axes are oblique with respect to one another at an angle of less than 90°, and said sputtering source is a magnetron sputtering source with at least one [toroidal] closed loop, tunnel-shaped magnetic field pattern around said first axis with [symmetric] constant field polarity [considered] as viewed in a [cutting plane through said new sputter surface and containing said first axis] direction along said closed loop.

47. (Amended) The chamber of claim 35, wherein said new sputter surface is substantially rotationally symmetrical with respect to said first axis and has a diameter Φ_T and wherein a locus of smallest mutual spacing of said first and of said second [axis] axes has a distance D to said new sputter surface and wherein $3/4 \leq \Phi_T /D \leq 2$.

48. (Amended) The chamber of claim 47, wherein Φ_T [= approx.] equals approximately 1.2 D.

50. (Amended) The chamber of claim 49, further comprising at least one of said substrate on said receiving surface, said locus being situated at least [approx.] approximately on a plane defined by a surface of said at least one substrate to be sputter coated.

58. (Amended) A method for manufacturing coated workpieces comprising the steps of

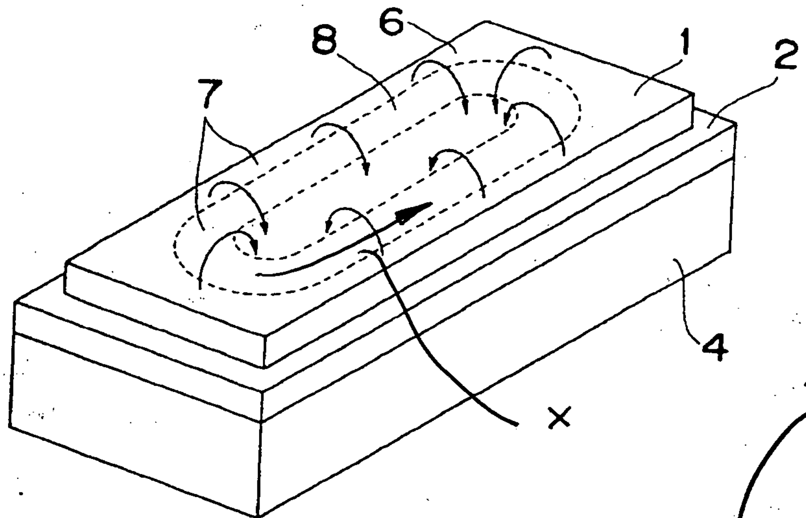
introducing a workpiece into a sputtering chamber,

rotating said workpiece about a rotational axis,

providing a sputtering source with a sputtering surface and having a central axis which is oblique with respect to said rotational axis at an angle of less than 90°,

sputter coating said workpiece by said source thereby providing at said source at least one [toroidal] closed-loop, tunnel-shaped magnetic field pattern with a [symmetric] constant field-polarity [consider] considered in a [cutting plane through said sputter source which contains said normal axis] direction along said closed loop.

Fig. 10 PRIOR ART



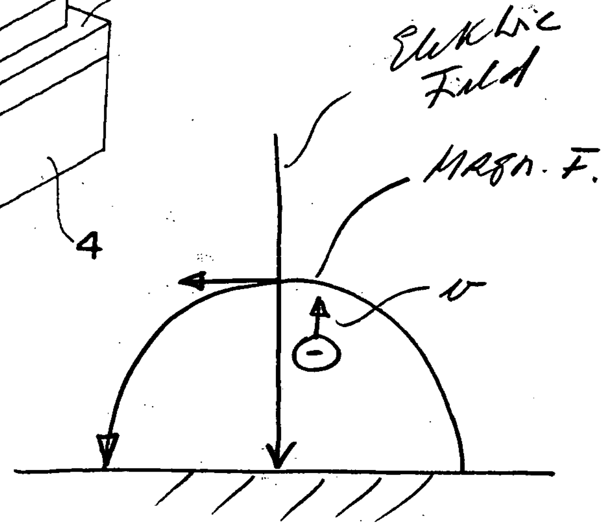


Fig. 12 PRIOR ART